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AUTHOR Hofmann, Thomas R.
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ABSTRACT

The descriptive contents (cognitive meanings) of the modals "can," "may," "could," "might," "must," "need," "ought," "should," compared with paraphrastic verbs and adjectives, motivate two cross-classifying dimensions: logical modality (possibility, impossibility, necessity) and linguistic modality (alethic, probability, authority, obligation, capability, ability, threat). Morphological suppletions and syntactic behavior of these modals verify this 7 x 3 matrix of English modals. The validity of these dimensions and of the terms in them is shown by a high degree of separation: few formatives are ambiguous by this analysis. Other languages such as Chinese and French have similar structures, but differ in the terms of linguistic modality. Logical modality, found in all languages with the same three terms, is based on a semantic atom /Imp/ in combinations with /Neg/. Some exploration of this object is pursued, into the realm of non-truth-functional connectives and the logic governing them. This element accounts for the sentence-connective nature of modals, and is the semantic basis of "if" and "because." A semantic definition of modality is proposed to account for the common perception of a class of modal verbs in languages where there is no syntactic or morphological motivation. (Author)

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modality 79/02/01-17: VERSION III

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Shimane Nat. University
Matsue City, Shimane, JAPAN

On Modality in English & Other Languages*

The descriptive contents (cognitive meanings) of the modals can, may, could, might, must, need ought, should, compared with paraphrastic verbs & adjectives, motivate 2 cross-classifying dimensions: "logical" modality (possibility : impossibility : necessity) & "linguistic" modality (alethic : probability : authority : obligation : capability : ability : threat). Morphological suppletions & syntactic behaviour of these modals verify this 7 x 3 matrix of English modals. The validity of these dimensions & the terms in them is shown by a very high degree of separation: few formatives are ambiguous by this analysis. Other languages such as Chinese & French have similar structures, but differ in the terms of linguistic modality.

The other dimension, logical modality, found in probably all languages with the same 3 terms, is argued to be based on a semantic atom /Imp/ in combinations with /Neg/. Some exploration of this object is pursued, into the realm of non-truth-functional connectives, & the logic governing them.

This element accounts for the sentence-connective nature of modals, as well as being the semantic basis of if & because. A semantic definition of modality is proposed to account for the common perception of a class of modal verbs in languages where there is no syntactic or morphological motivation.

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* This version (III) has been heavily revised in organisation, & the earlier 5x3 pattern of English modals has been extended to 7x3 with the discovery of 2 more classes. Within the 7 terms of linguistic modality, an interesting pattern has been observed. The terms 'epistemic' & 'deontic' are used here in a more general way, & more in keeping with their basic meanings.

Modality in English & other Languages*[1]

Modality, as we shall see shortly, is expressed by a variety of syntactic classes. By structural linguistic means, we may identify 2 dimensions of modality expressed commonly in language; logical modality dealing with possibility & necessity, & linguistic modality dealing with possibility or necessity in the social, physical, & epistemic domains. Contrasts in English for linguistic modality of possibility are: logical possibility, permissibility, allowance, capability & ability. There are also at least 2 other types of things that may be expressed with English modals, which do not form patterns with these: illocutionary forces (prediction in _will_ & promise in _shall_), & gnostic expressions (_can_ "know how to", _können_, _savoir_).

A major point of this discussion is to show that the semantic nature of natural language modality -- or at least its most prevalent type -- has been inadequately understood

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*[1] I would like to thank R.P.G. deRijk, M.L. Rivero, L.G. Kelly, B. Pottier, & R.S.D. Thomas for comments leading to the improvement of this discussion, & M. Pany, Zh-L. Zhung & M. Tajima for aid in exploring the modal systems of English, Chinese & Japanese.

& modelled, both in logic & linguistics. Natural language modals are not operators on propositions, but connective elements between propositions, on a semantic level of analysis. This point, though important, is sandwitched between the formidible & unending task of describing English expressions of modality, & the lengthy technique of implication tables in modal logic. Nevertheless, a semantic notion of modality is formulated.

To do this, we shall begin with a more complete systematic description of most of the modal verbs*2 in English, combined with other lexical means of expressing modality. This has as its primary goal a descriptive task, but the area of description is large enough that justification for particular items cannot be given in this short space. The primary technique of lexical paraphrase, though, is powerful. The result of applying it also to French & Chinese provides some idea of the nature of linguistic expression of modality, especially the 2 dimensions mentioned above, & some curious facts about the dimension of logical modality. Then, exploring the semantic nature of the English expressions of modality, we shall find reason to believe that the nature of modality is in connecting clauses. Lastly, I shall propose a logistic

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*2 Not all of the syntactic class of modals; see the section on modality for an accounting of the others.

system to account for these facts, as an alternative or extension to modal logics.

Throughout this discussion, we shall ignore totally the emotive possibilities that modals are often put to expressing. For example, "you CAN say that" implies disbelief but unwillingness to pursue the point. Such implications appear to derive from the context of usage as much as from the meaning of the modal. Indeed, the paraphratic expressions can be used in similar manners, "it is POSSIBLE to say that". I will thus assume that they should be accounted for with conversational implicatures.

Expression of Modality & paraphrastic elements in English & some other languages

In the tables to follow, the horizontal dimension (logical modality) is divided into 3 columns: /Pos/, /Imp/ & /Nec/. These are, to a 1st approximation only, "it is possible that ..", "it is impossible that ..", & "it is necessary that .." (in "philosopher's English"). As is well-known in modal logics, /Pos/ & /Nec/ are interdefinable, & /Imp/ is also, either as /Neg-Pos/ or as /Nec-Neg/. The a-priori logical 4th column, "possibly not" or "not necessarily" turns out to have no root morphemes in English or other languages studied, as will be remarked on below, & accordingly is not present in these tables.

The modals in the 1st 2 rows were distinguished from the rest as "epistemic" in Hoffman [Past], & were studied extensively by Newmeyer [English]. Deontic modality has been the subject of extensive modelling in recent studies in logic & is realised in English by the forms in the following 2 rows. Hoffman & others*3 totally overlooked the fact that the distinction between "epistemic" & "root" modals is present in the adjectives possible & necessary. At least 3 varieties of possibility can be distinguished with different complementisers:

he may be singing. it is possible that he is singing.
he may go play now. it is possible for him to go play now.
he can sing well. singing well is possible for him.

As well, Hermerén [Modality] distinguishes 3 classes in this dimension, which appear somewhat a-priori from the present standpoint, though clearly an improvement over Hoffman's 2 classes. Joos's [Verb] earlier "semiological cube" of English modals employed ever a 3rd dimension, but appears somewhat over-zealous in finding but 1 meaning for each modal.

By the methods employed here, the distinction epistemic:root appears only as a curious fact about the

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*3 e.g. Newmeyer [Root], Jenkins [Modality] or Woisetschlager [Semantic]. This distinction was proposed for adverbs in my 'Auxiliary topics: the Auxiliary Verb 4' (1967, polycopy, M.I.T.). & connected with different complementisers in my 'Epistemicity' (1969) Univ. Ottawa.

expression of past-time forms, & is abandoned until the end of this section, where the notion 'epistemic' reappears as a higher-level semantic category.

Table I is primarily the result of coordinating the distinctions between modals with the distinctions between adjectives which can paraphrase the different modal usages. This turns out to be a powerful technique, for reasons we shall see below. The verbs were added later, but only verify the set of equivalence classes already established. Syntactic details having no bearing on the semantic thrust of this discussion are given in an appendix, as there are many facts & claims here. Note also that not all usages of modals are given, as explained in that appendix; only the basic usages. As well, the hyphen in have-to, can't-help & had-better, & the inclusion of these forms in this study are explained there.

	/Pos/	/Imp/	/Nec/
ALETHIC			
Mo:	**may,could**	**can't,couldn't**	**must,have-to**
Aj[1]:	possible	impossible	certain
Aj[2]:			necessary
Aj[4]			sure, certain
Vb[1]:		block,prevent	imply,entail
PROBABILITY			
Mo:	**might**	**shouldn't**	**should**
Aj[1]:	possible	improbable,unlikely	probable,likely
Aj[4]:		unlikely	likely
Vb[1]:			suggest
AUTHORITY			
Mo:	**may,can**	**<may not>**	**have-to, must**
Aj[3]:	permissible	forbidden	obligatory
Aj[4]:	permitted	forbidden	required
Vb[2]	allow,permit	forbid	make, require
OBLIGATION			
Mo:	**can**	**shouldn't**	**should,ought-to**
Aj[2]:			obligatory,necessary
Aj[3]:			necessary
Aj[4]:	allowed	forbidden	obliged
		not supposed-to	supposed-to
Vb[2]	allow	prevent	oblige
CAPABILITY			
Mo:	**can**	**<dare not>**	**can't-help**
Aj[4]:	capable	incapable	compelled
ABILITY			
Mo:	**can**	**can't**	**have-to**
Aj[4]:	able*[4]	incapable,unable	
Vb[2]	let	stop,keep,prevent	make,force
THREAT			
Mo:		**had-better not**	**had-better**

NON-SYNTACTIC EXPRESSION OF MODAL-LIKE MEANINGS
Table I

What is most striking here is the fact that these modals can be paraphrased by non-modal expressions -- generally both by adjectives & by verbs. The fact that this can be done -- & done in a general way -- implies that in semantic

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*[4] In past-tense contexts (Leech [Meaning]), able, but not can, has an optional implication of successful completion with a completive verb.

terms, modals are not very different from verbs & adjectives; that the English class of modals is, such as it exists, primarily a syntactic one. We shall find reason to identify semantically a class of modal elements, however, including these modals & the adjectives mentioned here.

This table also shows clearly that the distinctions which differentiate modals 1 from the other permeate the English lexicon. This fact turns out to be useful in research on modals, & provided the epistemological basis for the present research. Looking at modals alone is not only more difficult, due to ambiguities & generalities of meaning, but the distinctions found between verbs & between adjectives often serve to lend clarity to a discussion of the meanings of modals. Moreover, the result of research on the syntactic modals alone is susceptible to being biassed by the syntactic pecularities of modals, namely that they are superficially monovalent (or single-place) predicates.

Table I, & thus the distinctions expressed in it, is supported 1st by the lexical distinctions claimed. Not only are the modals paraphrasable in certain ways, but they contrast with each other in 2 dimensions. Even more important is that these same contrasts are found among verbs & adjectives. The existence of this pattern is, strictly speaking, remarkable. While there are listed here

about 55 forms, distributed among some 21 cells (3 x 7) for an average of between 2 & 3 forms in each cell, only 2 forms appear in more than 2 cells: can, with its reputation for ambiguity, & have-to, apparently a case of a general meaning rather than ambiguity, which I would argue to be the case with can as well, as it realizes /Pos/ only, restricted to 4 terms of linguistic modality.

Students of the auxiliary verb in English should readily recognise the distinctions in the vertical dimension & their utility. I have made no distinctions not made traditionally, but have been able to minimize the semantically primitive elements by coordinating distinctions common to several modals. I have distinguished "authority" from "obligation" as there seem to be significant lexical differences in modals, verbs & adjectives between authority-based modality & social or moral modality. As well, I have distinguished ability from capability on the same grounds, though I am not sure that these are the best labels. Also proposed is a group of probability senses, to account for the so-called "probable" reading of should, "he should be arriving soon", & at the same time to account for a just perceptible difference between may & might in epistemic usage, "it may/might rain tomorrow". This distinction between the epistemic must & should proposed here deserves some justification, as it contradicts an explanation of Joos

[English], revived & argued for in Woisetschlager [Semantic]; that must marks a conclusion without conditions while should admits the existance of conditioning factors, & hence marks a conclusion which is not certain. The search for lexical paraphrases yields a number of items like probable & likely, but nothing like conditionally except as a complex & infrequent item. Of course, a probabilistic should (or likely) can be probabilistic for no other reason than there being some uncontrolled (or unknown) factors or conditions. Vice-versa, a should which entails the existance of other conditions must have a probabilistic truth value. Thus these 2 meaning-assignments, 'probability' & 'conditioned on other factors', mutually entail the other, so that we might say that they are equivalent. This will not do, however, as ceteris-paribus, I & most other linguisticians would prefer a discrete existance (or not) of other unexpressed factors or conditions which implies a probabilistic truch, rather than a fuzzy probabilistic explanation which implies other factors. This preference or intuition appears wrong, however, for 2 reasons: First, as other modals are paraphrasable, it would be surprising if should were not. Second, given 2 hypotheses about semantic structure of a language, one which used the same semantic elements in verbs, adjectives & modals, & the other which had a set of special semantic elements for modals, then the 1st must be

chosen if they both make the same predictions. This is of course is the strength (& weakness) of this paraphrase technique; it assumes that there will be semantic elements in common with other parts of the vocabulary, & tries to find them. In the present case, however, such common semantic elements are generally found, & I believe that we are forced to accept should as probabilistic.

Lastly, I have added a catagory "threat" (for lack of a better term) for 2 items often ignored by systematic syntactic accounts of modals, had-better & its negation had better not (also in British, hadn't better). The had is seldom realised in speech except as d*5, if that. Better can be replaced by best, with no apparent change in descriptive meaning, though it sounds more formal to me.

These vertical distinctions in linguistic modality can be motivated syntactically as well, by their different realisations with past-time adverbials, as seen in Table III below. The motivation for this particular ordering in the vertical dimension can also be found in the groupings in that table.

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*5 Historically, this d derives from would, which makes much better syntactic sense.

Some diagnostic environments for these different senses in the vertical dimension are given below for the modals. They are not perfect, but in a normal reading, they tend to select only 1 possible meaning. The subject of the sentence is apparently restricted to expressions designating human beings, or organisations or devices controlled by them, in expression of authority, obligation, & capability. If the verb is stative (Hoffman [Past] & Lakoff [Stative]) or achievement (Fillmore [Types]), the authority forms are excluded. This exclusion apparently applies to obligation, ability & capability items as well.

Alethic	he __ be singing; that much is sure.
Probability	he __ be singing, but I'm not sure.
Authority	you __ play in the rain.
Obligation	you __ cheat at Monopoly.
Capability	you __ ask her out.
Ability	I __ lift it; I've tried it before.
Threat	you __ be good, or the boogy-man'll get you.

Extracting the modals out of Table I, & adding the syntactic negative forms, we can observe several interesting facts in Table II. Numbering the linguistic modalities in sequence (1 = alethic, ..., 7 = threat), we see that can is used in senses 3, 4, 5, 6; apparently a case of general or non-specific meaning rather than any ambiguity of can. As well, have-to occurs in senses 1,3,6, but not in 2,4,5, while must restricted to senses 1 & 3, as is may. This seems to argue that these words are not ambiguous, & that

isolating specific usages of these words is wrong in the sense that it would be wrong -- uninformative & misleading -- to isolate usages of the word dog, 1 for terriers, an other for hounds, &c.

But more important for the present purposes is that the negatives of /Pos/-terms (except have-to which is only partially a modal) are invariably /Imp/ terms, even though they logically ought to appear in the 4th column. And as if there were not enough /Imp/ terms, negatives of /Pos/ terms also make /Imp/ terms, except for the epistemic (alethic) may, & for might (also epistemic). This makes for a surplus of synonymous /Imp/ terms, & a dearth of 4th column terms. The syntactic negation of have-to, "don't have to" is perhaps for that reason generalised; it is possible for every linguistic modality except probability, (1,3,4,5,6,7) not noted in Table II, even though the positive "have to" does not occur in half of these cases. It is perhaps also the reason for the appearance of needn't, whose positive form can be found only in special contexts such as tags & questions.

/Pos/	/Imp/	/Nec/	4th
Alethic			
may,could	can't,must not couldn't	must,have-to	may not
Probability			
might	shouldn't	should	might not
Authority			
may,can	may not,must not	must,have-to	needn't
Obligation			
can	shouldn't ought not	should ought-to	don't have-to
Capability			
can	dare not	can't-help	don't have-to
Ability			
can	can't	have-to	needn't
Threat			
--	had better not	had better	don't have-to

MODALS & THEIR NEGATIVE FORMS
Table II

Logically, the negation of a /Pos/ term should yield /Imp/, not-possible = impossible, while the negative of a /Nec/ term should make a 4th term (as with have-to). A number of these do not follow this pattern (e.g. must, should & ought), converting what ought to be a 4th term into /Imp/ terms, while the epistemic may/might pair express a 4th column meaning instead of the /Imp/ meaning as the authority may/might. The general pattern of negatives being /Imp/ terms, & the lack of 4th column terms, is found in other languages & will be returned to in the next section.

With past time adverbials, there are 3 different patterns of modification. First, there is simply the addition of the perfect (have + En) marker, called "past-tense replacement"

in Hoffman [Past], & later argued to be simply a realisation of past-tense in McCawley [Tense]. This occurs in the epistemic senses (the alethic & probability forms), & was used to identify them. Second, there can be a simple suppletive replacement, identical to the counterfactual substitutions in the appendix (e.g. may by might or must by had-to), as in the authority & ability terms, & in the generic senses (of can & will) as well. In the remaining cases, both things happen at once; a suppletive replacement & the presence of the perfect marker. This is found in the capability sense, & in obligation with /Pos/. E.g. "you could have asked her out yesterday; did you?", but *"you could ask her out yesterday". Otherwise the obligation follows the 2nd pattern. This 3rd pattern has befouled any serious attempt to use past-tense replacement as the sole identifier for epistemic senses, but fortunately can itself be identified by the present approach.

/Pos/	/Imp/	/Nec/	4th
Alethic			
could have	couldn't have	must have	may not have
may have	must not have	has-to have	doesn't have-to have
	can't have		
Probability			
might have	shouldn't have	should have	might not have
Authority			
might	mightn't	had-to	didn't have-to
could	couldn't		
Obligation			
could have	shouldn't have	should have	didn't have-to
	ought not have	ought-to have	didn't have-to have
Capability			
could have	dared not	couldn't-help	didn't need to have
			needn't have
Ability			
could	couldn't	had-to	didn't have-to
		needed to	needn't have
Threat			
	had-better not	had-better	

FORMS OCCURRING WITH PAST-TIME ADVERBIALS*6
Table III

The unsystematic results of negating a modal, e.g. adding -n't to a obligation or capability could have gives an alethic meaning, or inversely stated, the irregular ways of expressing denial (i.e. the denial of a /Pos/ is an /Imp/ & vice-versa) is easily verified, & gives more confidence in these tables, & the dimension & terms they are constructed on.

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*6 I have again written the modal-like have-to complex with a hyphen. The other haves are syntactically perfect markers realising past time or tense. They are generally pronounced without the 'h', with a reduced vowel, & sometimes with a loss of the 'v'.

The lack of morphological regularity in these tables merely reflects that this is a semantic classification, not a morphological one. The English modals have changed their meanings while some remnants of an earlier morphological system have been preserved.

This semantic structure of 2 dimensions, of 3 & of 7 terms, is thus supported by convergent data from lexical contrasts, & morphological & syntactic formations of negative & past-time forms. The general outline of the system, as described here for English, appears thus beyond question, though further pattern may be proposed (as we shall see shortly). Its integration into a general semantic theory is discussed below.

As a note aside, one can observe a perceptible pattern in the terms of linguistic modality;

	/Pos/	/Nec/
Epistemic		
Alethic	may,could	must,have-to
Probability	might	should
Deontic		
Authority	may,can	have-to,must
Obligation	can	ought-to,should*7
Capacity		
Capability	can	can't-help
Ability	can	have-to
Threat	-	had-better

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*7 I suspect that should (& Aj:supposed-to) should be distinguished from ought-to (& Aj:obliged) as weaker & stronger obligation. This would make 3 linguistic types of

Supporting the existance of natural semantic classes along these lines, have-to occurs for the 1st of each pair of /Nec/, while can can be used for the latter 2 pairs of /Pos/. If so, then these forms are not ambiguous, only less specific in meaning than the forms that fill only 1 position in this table. Woisetschlager's [Semantic] intuition of a common difference between must & should in the epistemic & deontic pairs also seems to be verified, & supports this pattern.

In French, Chinese, & other languages, we find the same pattern in logical modality (the horizontal dimension), but the distinctions in linguistic modality are particular to the language. The modal verbs in French & other languages do not belong to a syntactic category other than verb. Semantically, however, they are quite distinct from verbs that will paraphrase them, by the suppression of the 1st actant, as we shall see later.

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deontic modality, but so far, I have found no strong reason to do so.

	/Pos/	/Imp/	/Nec/
INELUCTABLE			
Mo:	**pouvoir**	**<ne pas falloir>**	**falloir**
		<ne pas pouvoir>	
Aj:	possible	impossible	nécessaire
			ineluctable
Vb:	laisser	empêcher	forcer
DEONTIC			
Mo:	**pouvoir**	**<ne pas devoir>**	**devoir**
Aj:	facultatif	interdit	obligatoire
Vb:	permettre	interdire,defendre	obliger
GNOSTIC			
Vb:	savoir*[a]	<ne pas savoir>	

FRENCH EXPRESSION OF MODAL-LIKE MEANINGS
Table IV

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*[a] The idiomatic translation of "he can speak French" is "il sait parler le français", where savoir may be thought to have a sense like /Pos/. I believe, however, that we must distinguish savoir & to know how from possibility /Pos/. Savoir is a necessary but not a sufficient condition for /Pos/. If the other necessary conditions are generally satisfied, as here the appropriate anatomical equipment is generally assumed, then by conversational implicature, savoir becomes materially equivalent to /Pos/. In Belgian varieties of French, savoir has come to replace pouvoir in other contexts.

	/Pos/	/Imp/	/Nec/
ALETHIC			
Mo:	kěnéng	<bukěnéng>	bìdìng,yídìng
PROBABILITY			
	kěnéng	<dàgài bù>	dàgài
AUTHORITY			
Mo:	kěyi	bùkěyi,bùxíng	(yídìng)dei,yídìngyàu
Vb:	ràng	(bùnéng)	shǐ
OFFICIAL POLICY			
Mo:	kěyi	bùkěyi,bùzǔn	yídìngyàu
Vb:	zǔn	bùzǔn	shǐ
DEONTIC			
Mo:	kěyi	bù(ìng)gai	inggai
DANGER			
Mo:	kěyi,néng	bùnéng,bùxíng	(yídìng)dei
Vb:		zǔai	shǐ
CAPACITY			
Mo:	kěyi,néng(gòu)	bùnéng	bìxu
suf:	-de-Prt	-bu-Prt	--
			(Prt=completive particle)
GNOSTIC			
Mo:	huì	<bùhuì>	--
			(ˇ for 3rd tone)

CHINESE*9 EXPRESSION OF MODAL-LIKE MEANINGS
Table V

/Pos/	/Imp/	/Nec/
ALETHIC		
suru kamoshirenai	suru hazuganai	suruni chigainai
DEONTIC		
shitemo ii	subekidewa nai	subekide aru
DEONTIC2		
shitemo ii	shitewa ikenai	shinakutewa ikenai
	surukotoga naranai	shinakereba naranai
ABILITY		
surukotoga dekiru	surukotoga dekinai	sezaruo enai
SUGGESTED		
	shinaihoogaii	suruhogaii
		Vb=suru

JAPANESE EXPRESSION OF MODAL-LIKE MEANINGS
Table VI

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*9 Standard Chinese, Báihuà (written) or Pǔtōnghuà (spoken), evolved historically from the Mandarin dialect. Other dialects differ mostly in pronunciation, with occasional morphemic substitutions.

French falloir differs from devoir, like English have-to from must, in not leaving open an obligatory connection to an other clause. The use of must or devoir indicate that a reason is to be found in the context. In the spoken language, it is impossible to say "he must go" or "il doit y aller" in a zero context. The source of the necessity must be given. On the other hand, either "he has to go" or "il lui faut y aller" can be used without any other sentence to tie to, though it is understood that there is something, expressed or not, which it relates to. This difference is analogous to definite pronominals, whose referents must be known if the sentence is to be complete. So must functions like "because of it", while have-to behaves more like "because of something".

The most striking aspect of all this data is the invariable presence of 3 terms of logical modality, /Pos/, /Imp/ & /Nec/, & the lack of morphemes for the 4th logical possibility. The remainder of this discussion will be concerned with the semantics of this dimension of logical modality, in the light that there is often an other dimension which cross-classifies with it & which may have different terms in different languages.

Terms of Logical Modality

The traditional modalities studied in logic (possibility & necessity), obligation modalities (ought & ought not), & other types of modality expressed in English, are represented above in terms of semantic elements /Pos/, /Imp/ & /Nec/. With an element of negation /Neg/, any 2 of these elements can be defined in terms of the 3rd. This gives the 3 possible sets of definitions below.

with /Imp/	with /Pos/	with /Nec/
Nec = Imp-Neg	Imp = Neg-Pos	Pos = Neg-Nec-Neg
OR	OR	
Pos = Neg-Imp	Nec = Neg-Pos-Neg	Imp = Nec-Neg

Modal logics, constructed formal languages which attempt to model natural language modality, have traditionally recognised only /Pos/, symbolised by a diamond ◇, & /Nec/, symbolised by a square □. Of these 3 sets of definitions above, the 1st alternative seems preferable, however, as it yields a symmetric solution whereby any natural language term of logical modality is defined in terms of at most 2 elements. If both /Pos/ & /Nec/ (or any 2 terms) were used as basic elements, there would have to be equivalence rules in the semantic representation, which would violate the notion of a semantic representation.

While it may seem unnatural to natives of West European languages to propose a term /Imp/ as semantically fundamental, when its expression (in those langauges) is obviously analysable morphologically, it must be remarked that some languages have unanalysable root morphemes (e.g. Eskimo ajugtug) for this /Imp/. But then, the English cant (as GBS would write it) is not far from becoming such an unanalysable formative, as is Russian nezlja, though it retains more clearly a negative element. Similarly, common expressions of modality in Japanese use terms meaning /Imp/, ikemasen (from authority) or narimasen (from propriety). Combining with the negative of the verb, these create /Nec/-terms, & with the positive verb, /Imp/-terms. These are both syntactically negative terms, but their positives are not used for the /Pos/-term; rather the general adjective ii 'good, okay' is used.

Negation /Neg/ with modals has long been recognised as having unusual semantic effects. Logically, sentence negation should convert a /Pos/ term into an /Imp/ term, or a /Nec/ term into a 4th column term. This holds without exception for adjectives, but not so for verbs & modal elements. Negation of /Nec/ modals typically makes /Imp/ as we observed for English above, & is more apparent in French & German below.

If /Imp/ is the basic term, Seuren's [Travels] question about negative-raising verbs could perhaps be answered; "Why are syntactic expressions of /Imp/ preferred to expressions of /Neg-Imp-Neg/?", rephrased in terms of a semantic element /Imp/. In any case, the absence of lexical items expressing this 4th term /Neg-Imp-Neg/ gives this question a wider scope. It will be noted, at least, that negative-raising converts a meaning like the a-priori 4th term into an Imp-like meaning. It is significant, moreover, that negative-raising occurs primarily in expressions with modal value. It occurs mostly with the verbs to believe & to think, when they have an epistemic modal value, & then only in the present tense -- i.e. in a performative frame. The occurrence of negative-raising with a verb probably is sufficient to identify it as being used in a modal or performative sense. A conversational implicature approach is sufficient to explain the meanings normally understood in a negative-raised structure but appears inadequate to explain why the negative-raised structures should be used in place of the semantically transparent structures.

The a-priori 4th term, /Neg-Nec/ or /Pos-Neg/, "might not", "possibly not", or "not necessarily" is for some reason not significantly lexicalized in any of these languages; while there are in English a dozen lexical realisations for /Pos/, & the same for /Imp/, & around 2

dozen for /Nec/, only <u>needn't</u> occurs in English for /Neg-Imp-Neg/ & even that form is not frequently used in modern English, at least in North America. It is not even a lexical unit, perhaps.

In French & German, the same facts about negatives & lack of 4th term appears.

/Pos/	/Imp/	/Nec/	4th
pouvoir	pas pouvoir		
	pas devoir	devoir	
	pas falloir	falloir	
können	nicht können		
	nicht müssen	müssen	

The absense is also found in Chinese, but this "improper" negation occurs with only a few items (bùgai).

Summarising these facts, the number of lexical realisations of /Pos/, /Imp/ & /Nec/, & the absence of the 4th term appears to militate in favour of /Imp/ as the basic semantic element (atom) out of which all others can be synthesized. We would expect, other things being equal, that frequent words would have simple meanings, & unlexicalised possible combinations of semantic elements to be relatively complex. In the table of past-time forms above, for example, the 4th column is striking for the number of formatives needed for each item. If either /Nec/

or /Pos/ were taken as the basic element, the other would be semantically more complex than the unlexicalised possibility. Moreover, negation of a /Nec/ modal often creates an /Imp/-term, even if that is the opposite of what sentential negation means. Nevertheless, I do not believ this constitues sufficient evidence for asserting any 1 of these possible analyses over the other.

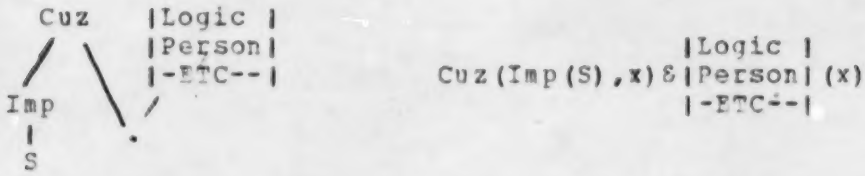
Semantic Structure

For the remainder of this discussion, I will speak only of /Imp/, for I believe that it provides the best basis for defining all 3 modalities. The same thing can be said, however, regardless of which of these 3 elements is taken to be basic.

One possible way to differentiate these 5 varieties of modality is to posit semantic features such as /Alethic/, /Authority/, ..., /Capability/, but this is clearly ad-hoc as these features do not find much other usage in the English lexicon or semantics.

If however, these features were analysed into a connecting relation plus some noun-like concepts, e.g logic, somebody, society,..., personality, we would be able to account for these differences with elements that must occur

in other parts of the language. Such a connecting relation might be /Cuz/ or what underlies <u>from</u> & <u>because of</u>. The S here stands for the meaning of the matrix clause.



Thus the epistemic <u>can't</u> in "John can't have gone" would receive a paraphrase "impossible from (because of) logic / logical reasons", as in "it is impossible from logic / logical reasons that John went". The corresponding authority modal in "John may not leave yet" would have a reading "it is still impossible from the reason of some person, that John leaves".

However, the epistemic modals are themselves clause relators on a semantic level. The sequence "He must have gone to the hospital. He is sick." imputes, ceteris-paribus, a notion of his illness being the CAUSE of his going. Similarly "He can't have gone to the dance. He is sick" implies the same causal connection. The simple concatenation of sentences without modals has a number of possible interpretations, with & without causality (see my [Dēscription] Ch IV), but note how the modal <u>must</u> for example marks the consequent sentence, & the relation between the sentences.

He didn't leave. He was sick. (¬L. S.)
He must not have left. He was sick. (¬L<=S.)
He didn't leave. He must have been sick. (¬L=>S.)

These causal connections are not the result of conversational implicatures, as we shall show with syntactic evidence below (clauses which are possible only if a modal is present). As well, a conversational implicature approach cannot attain even descriptive adequacy for the fact noted above that unlike have-to, must cannot be used unless the supporting reason is explicitly expressed nearby. We may conclude that these modals are integrative markers, & that the connections brought about by them are not the result of some type of conversational implicatures.

An other popular & rather traditional view is expressed by Michell [Indicating], who argued that "the function of modal adverbs [ie. obviously &c] is to mark conclusions in discourse." She then has problems in distinguishing conclusions from non-conclusions which becomes necessary in such a framework.

The present view is much simpler; modals relate clauses or independent sentences, & by virtue of that relation one of the clauses or sentences is called a conclusion.

Similarly Woisetschlager [Semantic: 114] informally defines D(x), P(x,y), & C(x,y) as derivation, premise &

conclusion. Then, "armed with all this apparatus", 3 primitives to acccunt for 1 item, he attacks the conclusionary (alethic) aspect of must as $\exists w[D(w) \& C(S^1,w) \& P(z,w)]$, to gain what the present analysis can by stating that there is an incompatability between the negative of the matrix clause & some other fact or facts; $\Box(\neg S^1 \& z)$ in the notation to be introduced below.

The possibility of an adverbial clause with for or if appears to be related to the semantic nature of modals, as in the examples below.

ALETHIC		must	
	he	may	have gone as he was sick.
		can't	
AUTHORITY		have to	
	you	may	go as you are sick.
		may not	
OBLIGATION		should	
	you	can	go as you are sick.
		shouldn't	
CAPACITY		can't help going	
	you	can go	as you are sick.
		can't go	

This clause-introducing as is slightly archaic, but is not possible without the modal in the main clause. The presence of these condition clauses is thus dependent on the modal, showing syntactically that modals connect clauses. For more modern English, the as can be replaced by for, if or because*[10]. (See Kimball [__] for for-phrases with the

adjectival paraphrases.) These last 2, if given the meanings proposed below, are redundant with the modal but differ in presuppositions. As well, they do not carry the vertical distinctions (in "linguistic modality") which modals do. Because these clauses in as, for, if & because are dependent on the modal, we cannot attribute their presence, nor the implications expressed by them, to conversational implicatures.

If we note a modal operator 'Mo' in a sentence "S" as "Mo*S", then we may propose the following as meanings for alethic must & can't, consistent with the above hypothesis. The "▼" stands for the proposition expressed by the adverbial clause, if present, or some appropriate adjacent sentence. The more general form of the meaning-structures proposed can thus be stated:

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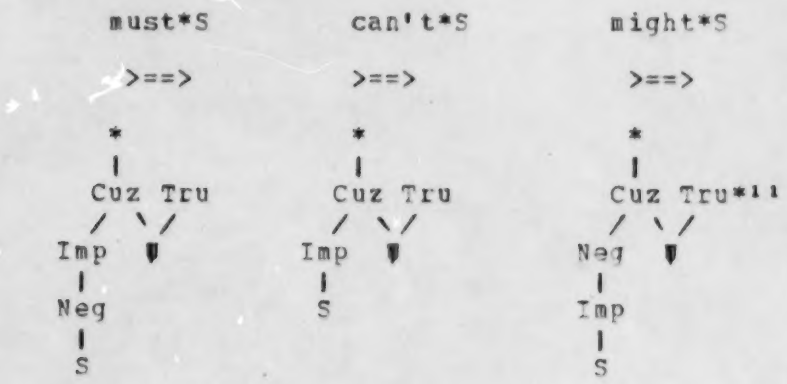
*10 Because is transformationally ambiguous; "it must be that he went because he is sick" or "it is because he is sick that he must have gone" are both adequate sources. Both of these sources are however logically equivalent by the method of "conditional proof".



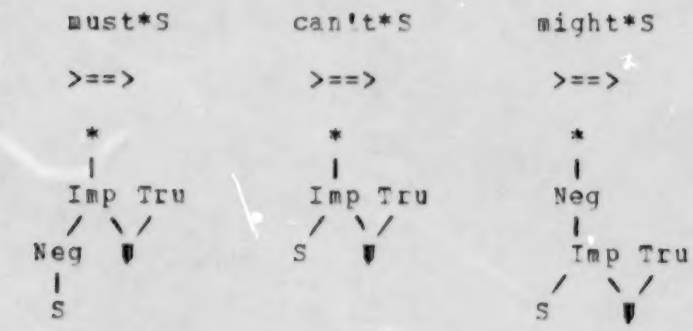
This is not dissimilar to the usual explanation of modals, treating the logical connection (/Cuz/) to the adjacent clause as something over & above the modals. That explanation however will not account for the paraphrasability by connecting verbs, nor for the presupposition of truth of the antecedent clause ▼.

This explanation is, moreover, complex, & more complex than the frequency of modal would lead us to expect, although it is within the spirit of logical analysis. However, as long as we are breaking with that tradition to introduce a new element /Imp/, we may go so far as to allow that this element /Imp/ can have more than 1 actant, with an interpretation that the propositions connected by it are not true at the same time, or that they describe incompatible

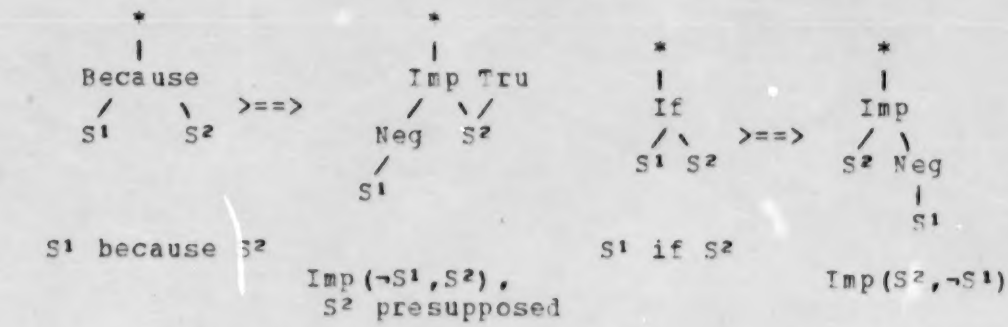
---

*11 The /Tru/ is needed to mark the presupposition of truth of the other statement ▼, as explained in my [Description, Ch III]. See below under the explanation for <u>because</u> & <u>if</u> for the predicate calculus translation of the presupposition.

events (or events in "complementary distribution"), we can reanalyse*12 these as;



This new element /Imp/ allows us to remove /Cuz/ from the list of semantic atoms, as it can be everywhere analysed, /Cuz(▼,ϕ)/ = /Imp(Neg(▼),ϕ)/, giving lexical rules for <u>because</u> & <u>if</u>;



Given that the alethic modals are connectives, relating 1 sentence to an other, we can now ask how the distinctions between modalities for English can be best represented. We

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*12 A substitution Imp(▼,ϕ) = Cuz(Imp(▼),ϕ) does not work in the case of /Pos/.

shall continue to consider only /Imp/ 'impossible, inconsistent', as the basic semantic element.

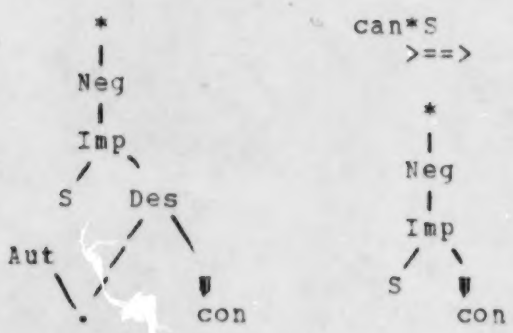
Clearly the authority interpretations mark propositions (possible events or actions) which are inconsistent with some authority. This has at least 2 possible interpretations; being inconsistent with accepting the authority of person <x>, or being inconsistent with what <x> (an authority which one accepts) desires or says. To say "May I go outside & play?" questions the consistency (or the lack of inconsistency /Neg-Imp/) of my going outside & playing, with the desires of the person accepted as authority. It clearly does not question the acceptance of that person as an authority.

This same notion of authority is found in many other places in English;

to obey, disobey (related to doing what an authority directs),
to direct, control, manage,...
(by virtue of money paid): boss, patron, employer, employee
(by other virtue): king, president, leader,
(in a limited domain): policeman, expert, ...

Without an extensive analysis, it would seem safe to accept there to be a semantic element describing a relation of authority /Aut/ from 1 person to an other. Then <u>may</u> of permission concerns the compatibility with the desires /Des/ or wishes of the person (or other being) accepted as authority.

may*S >==>



Neg(Imp(s,Des(x,▼)),
Aut(x) presupposed

can*S
>==>

Neg(Imp(S,▼))

Can is more general, concerning the compatibility of the matrix clause with something, unspecified. It can thus be used in places where may can, differing in these uses by not encoding the notion of authority as does may. Hence, quite accurately, I believe, may is restricted in usage to places where the speaker desires to make clear the relationship of authority. The fact that can is more commonly used in these places reflects a modern preference to avoid overt marking of authority relationships.

The other modals can be similarly explicated, taking care that the meanings assigned explain the total range of usage, without including possibilities that they do not have. For example, can is not used in an alethic sense, because it lacks the mention that the speaker accepts (or presupposes) as true the possibly conflicting facts.

Thus we find meanings for modals (& the verbs & adjectives mentioned here), to be based on notions of incompatibility with something else, often expressed in the context. This applies also for deontic & other senses, "He must go. He feels sick" or "He can't lift the box. He is sick." This is 1 more area where the semantics of words & sentences cannot be easily investigated in sentential semantic terms, but where sufficient & natural mechanism is found in a supra-sentential or integrative semantic theory.

Modality

The semantic notion of modality can now be broached. Although in French pouvoir, devoir, & falloir are not syntactically distinct from other verbs, & pattern with vouloir & others from a morphological point of view, it is commonly felt that they are "modal" verbs. The same is said of Chinese 'kěyi', 'nénɡ', děi', 'xīnɡ', except that they even lack any unusual morphology. Nevertheless, all these modal verbs can be paraphrased (in context) by ordinary transitive verbs such as we have included in the Table I for English, with their 1st actants (subjects, generally) not expressed in the sentence containing the modal. They thus function semantically like sentence-relating adverbs thus, therefore, hence, &c, which can be made explicit in an integrative semantic theory.

We can thus propose a semantic class of modality; a verb or adjective which connects 2 propositions by some notion of compatibility, of which the 1st actant is "understood" in the same sense that you is understood as subject in imperative sentences. That understood actant is commonly expressed as an adjacent sentence, or may be expressed as a subordinate clause in the same sentence, but there is no syntactic requirement to do this.

Novel here is the concept that modality deals with the semantic connection between sentences (or clauses), rather than being some sort of operator on the sentence. This position seems to imply that logical models of modality, the modal logics, are wrong-headed at best. We will see below, however, that those models can be reinterpreted to be valid for this linguistic notion of modality.

Not all of the semantically modal formatives of English belong to the English syntactic class of modals; have-to & can't-help are both semantically modals, but do not have the syntactic characteristics of modals (cannot be complementised by to or -ing, no s-form, no complementiser for their complements, fronted in questions), although they are both exceptional in other ways. The modal had-better is exceptional, generally having the syntactic characteristics of modals, but it does not appear at the front in questions

(except for a formal "hadn't you better go?", which only appears to be negative!). The syntactically normal verb need, as in "he doesn't need to go", is also semantically a modal, as it relates the matrix proposition ("he goes") to some other (unexpressed) fact by a relationship of incompatability.

As well, the English syntactic class of modals contains several elements which have primarily illocutionary meaning, especially: will & shall with predictive & promisory force as argued by Boyd & Thorne [Deep].

Modals expressing "generic" or "characteristic"*13 properties exhibit this same 3-term logical modality pattern.

	/Pos/	/Imp/	/Nec/
GENERIC			
Mo:	can	won't	will
Mo:	could	wouldn't	would,used-to
Aj:			usual
Av:	sometimes	rarely,seldom	usually,often
(more	extremely)	never	always

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*13 This usage of would has long been known, sometimes labelled "habitual". M. Pany is responsible for the discovery of can in this function, as in "she can be rather boring". C.f. the habitual "he would study all night when he was young" or "he will be an ass when he doesn't like someone".

These are easily accomodated to the conclusions we have reached about the other modals, namely that these express the various relationships of inconsistency with the "nature" or "character" of the referent of the subject nominal.

Note also that nominal quantifiers are found in this same pattern (c.f. Horne [Semantic]):

some no/none all

There appears to be a more general explanation yet to be found. I am not prepared, at present, to accomodate this nominal quantification to the present notion of incompatability, though it could be easily done.

Thus it is clear that the present semantic notion of modality bears no strong connection to the syntactic class of modals found in English, & few other languages, except that there is a large intersection between the syntactic & semantic classes. It should be noted, however, that the present notion of semantic modality is closely related to notions of predication & promise found in _will_ & _shall_, as well as to a generic performative as found in _can_ & _will/would_. With an appropriately extended notion of semantic modality, most uses of the syntactic modals in English will be included, but other things may be included as well, such as the performative elements in general.

Definition of /Imp/

To define this operation /Imp/, & to differentiate it both from /Neg/ & from /Neg-And/ (i.e. Shefter's [Sets] "stroke function"*14), we may construct "implication tables". This section is of interest primarily to logicians & mathematicians, but is also of interest as an example of a definition of a semantic atom. Nevertheless, it may be skipped with impunity by persons not interested in modal logic.

Implication tables are similar to "truth tables", except that they define all possible implications. For example, consider the truth tables for logical conjunction (&) & material implication (->).

A	B	A&B
T	T	T
T	F	F
F	T	F
F	F	F

A	B	A->B = ¬(A&¬B)
T	T	T
T	F	F
F	T	T
F	F	T

These may be expanded into "implication tables", where ( ) marks the inferable values. These tables define what are valid arguments. Here (?) marks the impossibility of a conclusion of (T) or (F), & (X) marks an inconsistency in

---

*14 Also known as "NAND" in informatics, & as "joint denial" in logic.

the assumptions of the argument. This puts us beyond truth-value logic, as '?' & 'X' are not truth values. To illustrate, take lines 5 to 8 of the implication table for '&' below: if A&B is T & A is T, then B must be T (line 5), while if A is F, we have a contradiction (line 7). If on the other hand, A&B is F while A is T, then B must be F (line 6), while if A is F, then we cannot determine the truth of B (line 8). Because of the symmetry of '&', lines 9-12 are the same with A & B exchanged.

I have added the natural language entailment "if A, (then) B", to contrast with the material implication "A->B". One of the problems with an explication of <u>if</u> by material implication is line 4; as Goodman [Fact] pointed out, it is impossible to accept the truth of "if Paris had been completely destroyed by atomic bombs in the last war, the author of this paper would stop smoking cigars in 1980", even though the antecedent is undeniably false. Comparing their implication tables, it is obvious that natural language entailment is grossly different (only 3 implications out of 12 are the same) from material implication.

	A	B	A&B
1	T	T	(T)
2	T	F	(F)
3	F	T	(F)
4	F	F	(F)
5	T	(T)	T
6	T	(F)	F
7	F	(X)	T
8	F	(?)	F
9	(T)	T	T
10	(F)	T	F
11	(X)	F	T
12	(?)	F	F

	A	B	A->B
1	T	T	(T)
2	T	F	(F)
3	F	T	(T)
4	F	F	(T)
5	T	(T)	T
6	T	(F)	F
7	F	(?)	T
8	F	(X)	F
9	(?)	T	T
10	(X)	T	F
11	(F)	F	T
12	(?)	F	F

	A	B	if A, B
1	T	T	(?)
2	T	F	(F)
3	F	T	(?)
4	F	F	(?)
5	T	(T)	T
6	T	(?)	F *15
7	F	(?)	T
8	F	(?)	F
9	(?)	T	T
10	(?)	T	F
11	(F)	F	T
12	(?)	F	F

The 1st 2 implication tables here are generated by inspection of the corresponding truth tables. The 3rd is simply the observation of what implications are valid for a natural language connective; "given you know something, what else can you know?"

We can now define /Imp(A,B)/ as "incompatible in general, for all pairs of events which can be described by A & B". The table at left, below, provides this definition, which is intuitively reasonable for the word "incompatible". To illustrate, if events A & B both happen (line 1), we know

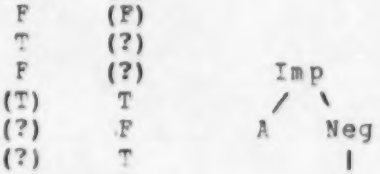
---

*15 This is a bit difficult to see. To claim that "if A, B" is false, while knowing that A is true, is tantamount to claiming that B is sometimes false, i.e. that A may or may not lead to B. Thus to deny "if he is let out of prison, he will kill somebody" while knowing that he has been let out of prison, is not tantamount to denying that he will kill somebody. Rather, that if he does kill somebody, it is not because he was let out of prison. The overt denial, "if he is let out of prison, he won't kill anybody", is the only syntactic negation possible, & is ambiguous between the negation of if-then & the negation of the consequent clause.

that they are not (F) incompatible. If however only 1 of them happens (lines 2 & 3), or if neither (line 4), we cannot argue (?) whether they are incompatible or not. Similarly, if we know A & B to be incompatible (lines 5&7) & we observe A (line 5), then we know B to be not true (F). But if we observe that A does not occur (line 7), we cannot argue (?) whether B happens or not. And if we know that A & B are compatible (lines 6 & 8), whether or not A occurs, we cannot argue (?) whether B occurs or not. Lastly, because /Imp/ is symmetric, the last 4 lines are the same as the middle 4, with the exchange of A & B.

A	B	Imp(A,B)
T	T	(F)
T	F	(?)
F	T	(?)
F	F	(?)
T	(F)	T
T	(?)	F
F	(?)	T
F	(?)	F
(F)	T	T
(?)	T	F
(?)	F	F
(?)	F	F

A	B	Imp(A,Neg(B))
T	T	(?)
T	F	(F)
F	T	(?)
F	F	(?)
T	(T)	T
T	(?)	F
F	(?)	T
F	(?)	F
(?)	T	T
(?)	T	F
(F)	F	T
(?)	F	F



At right is given the implication table for a complex function involving /Imp/, /Imp(A,Neg(B))/. Note that its implication table, i.e. the possible arguments based on it, are identical to that of "if A, (then) B", above. It is thus an adequate explication for natural language entailment. As it is also the primary element underlying

modals, the relationship between entaillment & logical modality can be easily accounted for.

A simpler implication table may be used for the * definition of /Imp/ & modality, by defining a function 'never', ⊠, as at left below*16. In the middle, the implication table for ¬⊠A is given, where double parentheses (( )) indicate the ultimate implication. The single parentheses ( ) mark an intermediate implication, used in calculating the ultimate implication. Compare these ultimate implications with the implication table for the modal logic element 'possibility', ∇, at right.

A	⊠A
T	(F)
F	(?)
(F)	T
(?)	F

DEF

A	⊠A	¬⊠A
T	(F)	((T))
F	(?)	((?))
((?))	(F)	T
((F))	(T)	F

A	∇A
T	(T)
F	(?)
(?)	T
(F)	F

DEF

Note the implicational differences between ¬ & ⊠, not & never:

---

*16 ⊠ is an into function on the set {T, F, ?}, which have the interpretations, "known True, known False, & unknown", & we must add a line after line 2: ? (?). But this simple application of function theory does not appear adequate to say all that should be said about ⊠, including lines 3, 4, & a line after 4: (?) ?. Alternatively, we can describe ⊠ as a relation {<T,F>, <F,T>, <F,F>} in the set {T,F}, whose inverse $\boxtimes^{-1}$ is identical to it.

TRUTH TABLE

A	¬A
T	F
F	T

IMPLICATION TABLES

A	¬A
T	(F)
F	(T)
(F)	T
(T)	F

A	◻A
T	(F)
F	(?)
(F)	T
(?)	F

/Imp(A,B)/ can now be defined as ◻(A&B), below. Then, if, because & the logical modalities /Pos/ & /Neg/ can be defined as above in terms of /Imp/.

A	B	A&B	◻(A&B) = Imp(A,B)
T	T	(T)	((F))
T	F	(F)	((?))
F	T	(F)	((?))
F	F	(F)	((?))
T	((F))	(F)	T
T	((?))	(?)	F
F	((?))	(F)	T
F	((?))	<F>	F
((F))	T	(F)	T
((?))	T	(?)	F
((?))	F	(F)	T
((?))	F	<F>	F

<F> = F because a conjoint is F

If the elements of modal logics, e.g. □A or ◇A (Nec-A or Pos-A), are accepted as sentence relations, then □A = ◻(¬A&B), and ◇A = ¬◻(A&B), where B is unspecified. Under this interpretation of modal logic, however, ◇ should be read "is compatable" & □ should be read "is entailled", & modal logic seems to disappear as distinct from ordinary logic.

For simplicity of axioms, this monadic (monovalent) ⊠-function is to be preferred. In the sense that addition can be used to define all arithmetic fuctions, subtraction, multiplication, division, & then roots & powers, it is preferred in an axiomatic system to use as the fundamental operator.

However, we are not engaged in discovering an axiomatic explication for English or other natural language. We are, to be sure, attempting to minimize the number of elemental semantic units, semantic atoms. Nevertheless, we limit this minimization to not positing semantic elements smaller than those needed to explicate the smallest contrasts in the language. For this reason, there is no motivation to utilize the monovalent ⊠-function as any different from a polyvalent /Imp/ function.

The difference between never ⊠ & not ¬ (or equivalently, between /Imp/ & the /Nand/ or /Neg-And/ mentioned above) is the universal nature of ⊠. The truth value of /Nand(A,B)/, & thence all the so-called logical truth functions, can be determined from the truth of the component propositions, A & B, although the truth value of 1 of the components cannot always be determined from the truth value of the complex proposition & the other components. For example, line 8 in conjunction & line 7 in material implication (in the 1st

implication table) have indeterminate truth-values. The natural language connectives (including □ & /Imp/) have indeterminate values (?) not only for whole to parts, but also from parts to whole. Thus they are not truth-value functions, as their truth values can not always be determined by the truth values of their component propositions. They are rather definable on, & mapping into the set, {known-true=T, known-false=F, unknown=?}.

A formal argument "A, B, C, therefore D" is valid iff (A&B&C)->D is a tautology. Let 'ABC' be a conjunction of any number of premises, & '⊣' be prefixed to indicate "is a tautology". Then ⊣(ABC->D) has exactly the same implication table as □(ABC&¬D) or Imp(ABC,¬D). It follows that "▼ is a tautology" ⊣▼ = □¬▼. If "must*D" has a meaning /Imp(ABC,¬D), where ABC is some other clause or clauses, it is clear why must is used to mark conclusions of arguments.

The "functions" □ & /Imp/ are, in a sense, universally quantified over all instances, or alternatively, over all possible universes. This universal quantification appears to be a necessity for systems or languages which allow only general descriptions. Any statement or proposition in natural language describes an infinite class of events, unlike most logical notations which evolved for & allow expression of instance statements. Even given no problem in

reference, i.e. supposing that the referents are fixed, there is an infinite class of events which can be properly described by any predicate. Even uttered at a specific time & place, referring to a specific thing, the sentence "it is red" is true for an infinity of different states of affairs, the various shades of red. We talk about specific events with general descriptions. There is not much use in such a language to have a special connective such as material implication, "it is not true that both an event of class A occurred & none of class B did". More useful are; "an event of both class A & B occurred" (descriptive conjunction), "an event of class A & an event of class B occurred" (logical conjunction), "an event of class A did not occur" (negation), & even "either an event of class A or an event of class B occurred" (logical disjuction). Thus natural languages seldom if ever have a connective for material implication, "no event of class A occurred, or else an event of class B occurred, or else an event of class B & none of class A occurred."

Natural entailment & incompatibility in general*17 are related to "if an event of class A occurs, then no event of class B also occurs" or "events of class A are incompatible with events of class B" (logical incompatibility) & "a

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*17 The notions; "complementary distribution" in phonology, "paradigmatic relations" in syntax, "inconsistent" in logic, & "exclusive events" in probability theory & statistics.

description of A is incompatible with a description of B for an event" (descriptive incompatibility). Hence we shall accept /Imp/ as a 2-actant (dyadic or bivalent) relation, & allow a monovalent (1-actant) usage as an abbreviation, /Imp(A)/ standing for /Imp(A,A)/.

Actually, I expect that the natural language definition given for /Imp/ at the beginning will turn out to be more appropriate than a bivalent /Imp/ as formally defined, in so far as it is not limited to relating only 2 propostions. Rather, a polyvalent /Imp/, taking any number of propositions, will include the monovalent & bivalent usages proposed here, without treating 1 as an abbreviation. Moreover, with 3 or more propositions linked by bivalent /Imp/s, there are 3 or more logically equivalent but formally distinct structures, which appear to have no linguistic or logical reality.

In the latter part of this discussion, we have defined a function ⊠ in the set {T, F, ?}, & shown that several things can be defined from it: the modal logic operators ∇ & □, validity of an argument, & even tautology in general. Its real purpose here is, however, to serve as a mathematical basis for /Imp/, which apparently underlies natural language modality, as well as <u>if</u> & <u>because</u>.

This bivalent /Imp/ underlies directly the alethic modals, thus explaining their connective usage. In other, non-epistemic usages, the modals relate to an incompatibility with something, which may be expressed to some degree in the choice of modal.

Conclusions

Based on converging morphological, syntactic & lexical evidence, we have seen a matrix of semantic contrasts underlying the English modals. At very least, I hope that this method will provide some basis for research on English modals other than the eternal collection of citations, culled from immense texts or from the imagination (or from other grammarian's examples), for each modal, few of which have more than 2 positions in this matrix, some of which are simply less specific in meaning. Worse than being merely tedious butterfly-collecting, that method then collects the citations for each word together on some ad-hoc basis to form unprincipled groups of usages called readings or senses. Nearly all traditional work on the English modals has been of this sort; see Quirk &al [Grammar], Leech [Meaning], Palmer [Study], or Joos [Verb], for some recent examples. At least Joos & Palmer tried to make systematic explanations. It is not surprising that so much effort has gone into such activities, with little advancement, given

that there is no systematic way to collect citations into senses. As well, the result of that activity is useless tables or even books, which give many senses for each possible word, instead of something that can be an aid in teaching a language, or can shed some light on the nature of language itself.

But more than this, we have found suggestive patterns in the terms of linguistic modality. And even more interesting, logical modality may be universally realised with the same 3 terms. I could hope that these leads may be proven or disproven. As well, the other sorts of things realised in English modals, including illocutionary potential in shall & will can also be related as they are a type of modality in a broad sense*18, which includes performative & complementisers. I regret that time has not allowed me to pursue these directions as well.

In a narrower sense of modality, we have also proposed a semantic notion of modality which applies to all languages, & have seen syntactic & semantic evidence that modals are sentence connectives like conjunctions (if, because) & certain sentential adverbs (thus, hence, therefore).

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*18 Such as used in Ransom [Representation].

Lastly, I have proposed a mathematical element 'never', ⊠, not dissimilar from the elements, ◇ 'possible' & □ 'necessary', of modal logics, to underlie them & the connective nature of natural language modality. To show this, the "implication table", a modal logic analogue of the truth table, was introduced, to allow simple calculation of truth values of modalised propositions.

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- - - A P P E N D I X - - -

Syntactic Details of Description

In Table I, Aj, Mo & Vb stand for adjectival, modal & verbal realisations of the semantic content in question, with superscripts designating subclasses. The superficial syntactic patterns involved here (with a matrix sentence of NP Ts VP) are roughly:

Aj^1: it is Aj^1 that NP Ts VP
Aj^2: it is Aj^2 that NP ϕ VP *1
Aj^3: it is Aj^3 for NP to VP
Aj^4: NP is Aj^4 to VP / of Ing VP

Mo: NP Mo VP

Vb^1: S^2 Vb S^1
Vb^2: NP^2 Vb S^1

The S^2 in the pattern with Vb^1 stands for an other clause, syntactically required in this pattern, & optionally expressed in the same sentence by an *if*- or *for*-clause in most other patterns. See discussion about its semantic value. It is called the 'antecedent' clause here, as these structures are generally paraphrasable in an *if*-*then* structure, with this clause as the *if*- or antecedent

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*1 In the Aj^2 pattern, ϕ marks the lack of Ts, forming a *that*-clause without Ts, the so-called "co-actual subjunctive".

clause. Aj^1 can also take a nominalized clause as subject, "NP's ing VP is Aj^1", virtually requiring the expression of an "antecedent clause" S^2.

Note that the alethic Aj^1 can be used as Aj^3, & then lose their epistemic sense, apparently neutralized between the remaining senses.

Adverbs, not included here, may be regularly formed with -ly for Aj^1 & Aj^2 patterns, except in the /Imp/ column (& except for likely which is its own adverbial formation). The verbs are transitive, semantically linking the qualified proposition (their syntactic objects) to whatever it is which makes it possible, impossible or necessary: their syntactic subjects. These subject expressions are not obligatorily expressed with modals, but may generally be expressed as a preceeding or following sentence. Angle brackets < > enclose non-lexical, i.e. syntactic, formations which fill an otherwise empty slot.

The forms listed in Table I are ONLY the isolatable BASIC forms. There are means whereby other forms can be created, forms which cannot exist in isolation. For example, in the epistemic modals, one can easily say "he can't have gone, can he?" This might lead to a superficial conclusion that can is 1 possible realisation of epistemic possibility. Yet

it can do so ONLY in the immediate context of a can't in that sense. There is no "he can have gone"*z. Whether one posits tag-formation by "denegativisation" or some other explanation, can does not exist in an epistemic sense unless with /Neg/ or in a context of such a can. Thus only can't, & not can, is listed in the alethic sense.

I have listed have-to hyphenated to indicate that it is an idiom like can't-help, as it regularly has the final consonant of have (or has or had) devoiced. It is listed as a modal as well, although it differs significantly from modals in syntactic behaviour, for it is semantically a modal by the characterisation we shall find later. If not listed as a modal, moreover, we should have to add an other type of verb, which appears in just those places where no syntactic /Nec/ modal exists.

Somewhat ilogically, perhaps, I have listed supposed-to as an Aj* (it takes be) with its to although this to is regularly required in this pattern. It is so listed to mark the (historical) devoicing of supposed, which would be better spelled spost in contemporary English, & treated as a predicative adjective.

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*z Palmer [Study] has such constructions as possible, but I can find no trace of them except in questions, especially tag questions.

For the counterfactual clause of English (e.g. after to wish), there is a simple replacement, with appropriate adjustments for not. Apparently the same replacements are used for adjustments required by the sequence-of-tenses rule.

may	can	have-to	must	need	dare	should	
might	could	had-to	had-to	had-to	dared	should	have-to

REPLACEMENTS FOR COUNTERFACTURAL & TENSE-SHIFTING

The 1st 2 of these replacements (might & could) occur also in polite & formal contexts.

I will not give justification or examples for the placement of items in Table I, as it is not my purpose here to make a dictionary. As well, these placements reflect merely my own formal dialect, though I believe it to be fairly standard contemporary formal English. However, these placements may be biassed in the direction of exaggerating the clarity of the pattern.

Below are some nominal expressions of modalities,

N¹ the ___ that NP Ts VP
N² NP's ___ to VP

	/Pos/	/Imp/	/Nec/	4th
Alethic				
	N^1 possibility	impossibility	certainty	
Probability				
	N^1	improbability unlikelihood	probability likelihood	
Authority				
	N^1 permissibility	?	necessity requirement	freedom
	N^2			freedom
Obligation				
	N^1 permissibility		obligation	freedom
	N^2		obligation	freedom
Capability				
	N^2 capability	incapacity	compulsion	
Ability				
	N^2 ability	inability		
Threat				
	N^1	risk		

These nominals show the validity of the distinctions, & the unambiguous appearance of necessity for authority suggests that the use of necessary in an epistemic sense is a recent innovation.

As the question forms are not always the same as the declarative forms, we can make a table of them also. Here we consider only the form used in "neutral" questions, questions that do not elicit a positive answer as do negative questions like "didn't you do it?"

	/Pos/	/Imp/	/Nec/
Alethic	might,could		can't must
Probability	might		should
Authority	may,can		do have-to
Obligation	can		should
Capacity	can	do dare to	can't-help
Ability	can		do have-to

As is clear from even a cursory comparison of these tables with the other tables on English, this area is a challenge for a theory of the lexicon (exceptions in lexical insertion). These exceptions do nothing here except to add further support to the distinctions already drawn.

Adding (P) for a violation of presuppositions, we can make an implication table for <u>because</u>.

A	B	B because A
T	T	(?)
T	F	(F)
F	T	(P)
F	F	(P)
T	(T)	T
T	(F)	F
F	(P)	T
F	(X)	F
(T)	T	T
(?)	T	F
(P)	F	T
( )	F	F

Examples
2: he went & its not raining.
So it must not be that he went because its raining.
10: I know he went,
but its not T he went because its raining...may be raining or not.

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n2: 5 (right-shift) s2: (opti
n1: 623 (paper) s3: tn (qu
n0: 3 (copies) s6: Hofman